

Pressure stimulus study on acupuncture points with multi-channel multimode-fiber diffuse speckle contrast analysis (MMF-DSCA): supplement

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Supplement DOI: <https://doi.org/10.6084/m9.figshare.24230461>

Parent Article DOI: <https://doi.org/10.1364/BOE.502447>

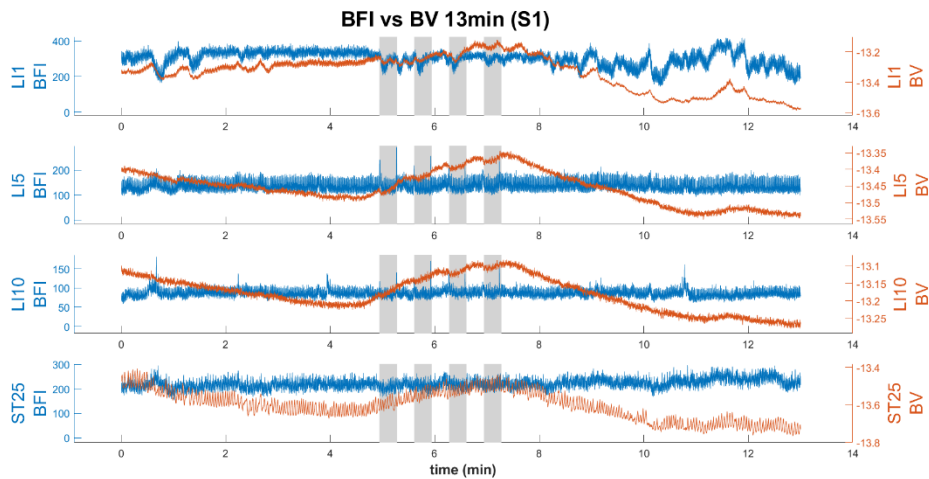
PRESSURE STIMULUS STUDY ON ACUPUNCTURE POINTS WITH MULTI-CHANNEL MULTIMODE-FIBER DIFFUSE SPECKLE CONTRAST ANALYSIS (MMF-DSCA): SUPPLEMENTAL DOCUMENT

1. Blood Volume (BV) data with pressure stimulus for all subjects

Blood volume (BV) data for all channels from all subjects are shown below, along with the blood flow index (BFI) data for comparison.

Macroscopically, BFI value moves within the narrow region except for cases of motion artifacts, but BV tends to show decreasing trend for both baseline and release period, and increasing trend during stimulus. The decreasing trend could be non-physiological, and could be probably explained by gradual deterioration of light coupling between fiber and tissue, as we have used a strap-based support around subject's arm and belly, and the increasing trend during pressure stimulus could be physiologically explained by local blood pooling effect and some possible systemic change (increasing heart rate, for example).

Despite the trend, the overall change between before and after the stimulus is not statistically significant, so we have not included the analysis in the text. BV measurement is highly sensitive to light coupling efficiency between probe and tissue, so BFI measurement based on speckle contrast should be regarded more robust and trustworthy in the long time scale. Still, whenever BFI shows changes, BV tends to follow the change with a lag, and we can see that BV signal behaves as if it were an integrator or low-pass filter of BFI signal..



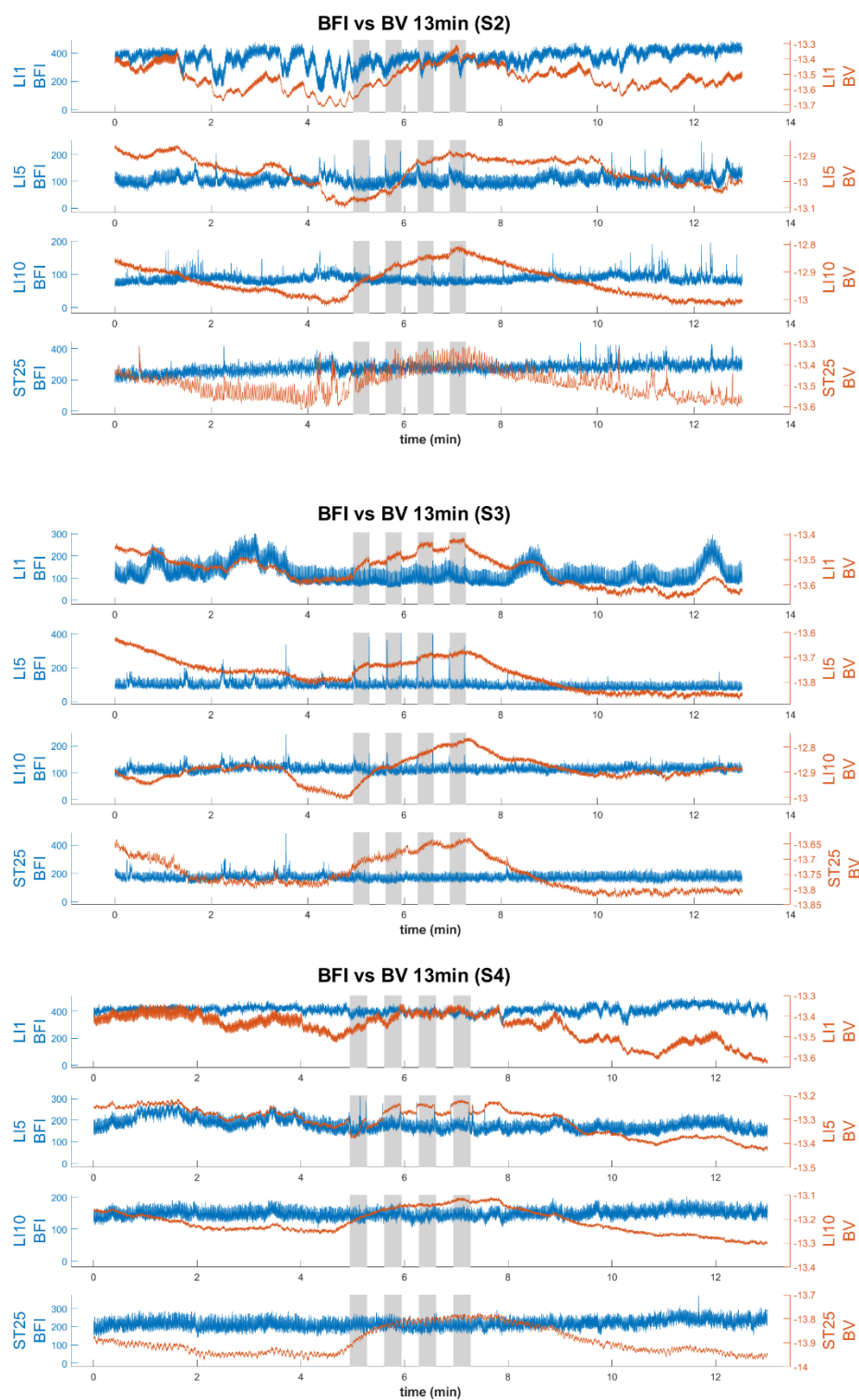


Fig. S1. Concurrent BFI and BV graphs for four channels on all subjects

2. Blood flow index change for all subjects with pressure stimulus

Blood flow index (BFI) for all four channels from each subject (S1~S4) is shown below as a series of bar-graph (for comparison among channels) and line-graph (for comparison among different time points)

One should note that individual BFI levels on each acupoint do not show significant change before and after the pressure stimulus, but their individual baseline variation is huge and there seems to be no patterns observed.

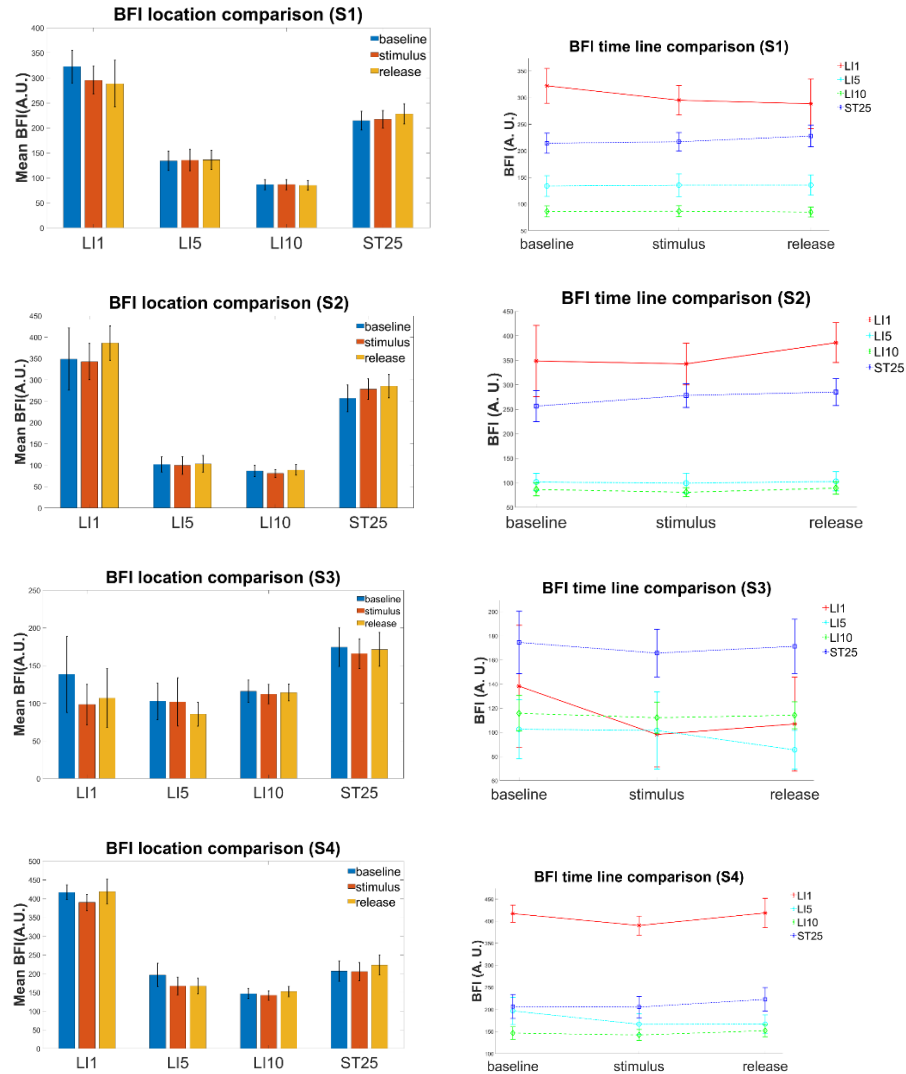


Fig. S2. BFI comparison for four channels on all subjects

3. Heartbeat signal patterns observed from both BFI and BV

Both BFI and BV signal, when zoomed in, shows well-defined heartbeat patterns, especially on LI1 (fingertip) acupoint. Heartbeat signal is more prominent and sharper on BFI signal, and BV peak tends to lag a little bit behind BFI peak, as literature reports (For example, Bi et al, Fast pulsatile blood flow measurement in deep tissue through a multimode detection fiber, Journal of Biomedical Optics 2020, Ref[14]) In the figure below, what is labelled as PPG should be understood as BV.

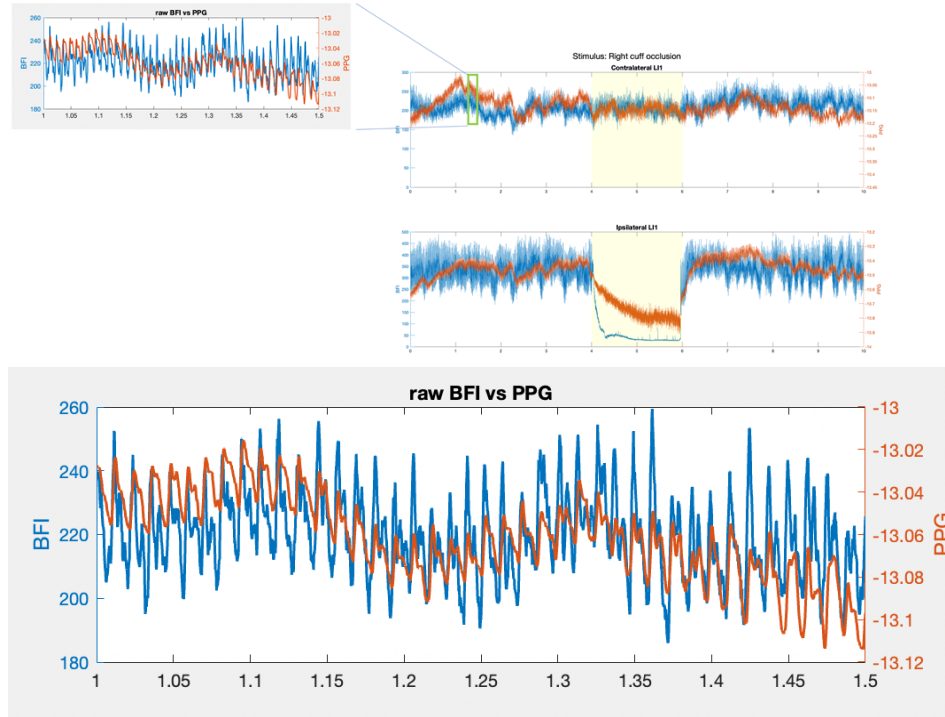


Fig. S3. Magnified version of BFI and BV. Heartbeat signals are clearly seen, and the peak location can be compared.

4. Noise consideration in validation study

Some more details about validation study (sections 2.2 and 3.1 in the main text) are described here. The experimental setup was as seen in the picture below, where only the right arm was gone through cuff occlusion, and a solid phantom occupies one channel as well.

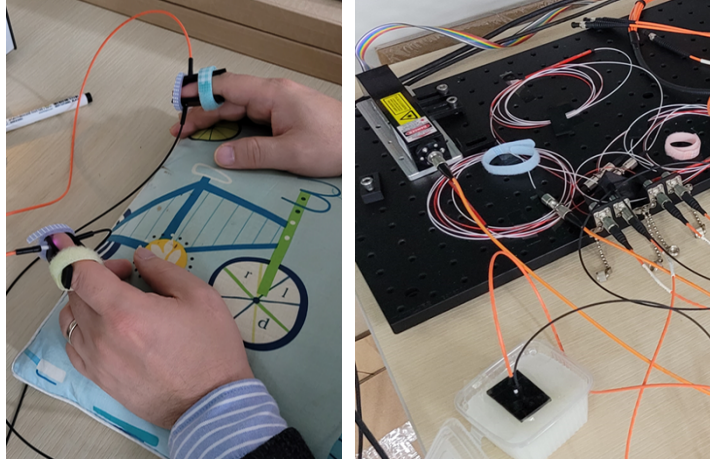


Fig. S4. Experimental setup for validation study using cuff-occlusion protocol

The result shows nice drop of BFI and BV only from the right LI1 (Fig 4). A solid phantom was connected to one channel mainly to observe the stability of source laser, and it shows mild fluctuation around BFI of 30, as shown in the bottom of Fig 4.

The reason behind this rather high number of BFI needs to be discussed. The BFI data shown in Fig. 4 is calculated from each raw CCD image taken without any data pre-processing,. We have estimated the magnitude of K^2 due to each type of noise (shot, dark, read, and quantization error) by using our experimental parameters ($Q_e \sim 35\%$, $T_{exp} \sim 2ms$, $c_s \sim 10,000/s$) following [Zilpelwar BOE 2022], and they were quite negligible compared to K_{all}^2 , and cannot be a determining factor. The main factor, in retrospect, is believed to be the stray light making its way to CCD through phantom or human tissue, as we performed experiment under the flickering room light ($\sim 120Hz$) that tends to lower the speckle contrast